Special issue: Global examination of green infrastructure, urban greening concepts and projects – the role of impact assessment

Paper title

Progressing Green Infrastructure planning: understanding its scalar, temporal, geo-spatial and disciplinary evolution

Abstract

Growing recognition has developed between policy-makers and practitioners that green infrastructure (GI) provides an approach to planning for effectively integrating ecosystems, biodiversity, socio-economic and political factors into a coherent framework for environmental management. While there has been progressive development of the concept, a deeper analysis demonstrates that this process has been disjointed. We identify four factors or 'axes' related to: *temporal*, *geographic*, *scalar*, and *disciplinary* variation, which have shaped how GI is promoted and implemented. This paper traces coalescence and divergence across GI planning, using these four axes to map the concept's development. It also questions whether the lack of alignment between GI research and Impact Assessment (IA) is grounded in existing disciplinary mentalities or related to governance or geographical variation. From this analysis, we identify that these factors interact with socio-political and economic drivers shaping the terminology used, but this is not translated into effective evaluative practice. Although flexibility is one of the main strengths of GI, we argue that some degree of harmonisation will help advance the use of GI in environmental planning and assessment.

1.0 Introduction

Rapid urbanisation coupled with unprecedented rates of habitat loss has placed an increased emphasis on the role of urban green spaces to provide ecosystem services (Lovell and Taylor, 2013). In addition, there is a growing recognition that green spaces, under certain conditions, can contribute to solving multiple environmental challenges, including climate change (Gill et al., 2007), air quality (Jayasooriya et al., 2017), ecological connectivity (Benedict and McMahon, 2002), human health (Tzoulas et al., 2007; WHO, 2017), and poverty alleviation (Dunn, 2010). Concurrently, cities face significant challenges in maintaining green spaces due to myriad political and socio-economic factors. Growing recognition of these influences, their impact on liveability, and evaluation of their impacts underscores the need for a concept supporting an integrated approach to landscape and urban planning.

Green infrastructure (GI) has emerged as one such concept, promoting the role of green spaces in achieving sustainability objectives (Mell, 2009). Moving beyond the basic recognition that green spaces are important (Wilson & Hughes, 2011), GI considers how planners and environmental managers can optimise the multiple functions and benefits of ecological resources. GI has also acted as a concept with a set of guiding principles, namely: connectivity, multi-functionality, access to nature, integrated policy/practice, and an understanding of the socio-economic and ecological benefits of effective landscape management, around which environmental advocates have coalesced (Austin, 2014). GI has therefore emerged as a means of aligning socio-cultural needs with the provision of ecosystem services and ecological connectivity, promoting a more integrated approach to environmental management (Mell, 2015). Moreover, there is a growing recognition that GI is contemporary terminology integrating a series of existing environmental practices into a more holistic framework for landscape management (Benedict & McMahon, 2006; Fischer, 2016).

Within this paper we assess GI as an approach to planning, based on evidence from the USA, UK, western Europe, and South and East Asia[1], that draws on the conceptual understandings of the physical environment and the associated networks of socio-ecological resources identified within them. GI advocates have also looked to Greenways, Garden Cities, urban forestry, and more recently nature-based solutions (NBS) to structure the conceptual grounding for GI (Austin, 2014). The inclusion of such variability can be seen in the definition of GI by Benedict and McMahon (2002:12) who stated that:

> Green Infrastructure is an interconnected network of green spaces that conserves natural ecosystems values and functions and provides associated benefits to human populations. Green Infrastructure is the ecological framework needed for environmental, social and economic sustainability.

[1] These locations have generated the most significant number of academic journal articles/outputs related to GI. A growing evidence base though is developing focusing on African and Latin American cities; however, GI research remains dominated by research focused on Northern Hemisphere examples (Kabisch et al. 2015).

Benedict & McMahon synthesised the initial commentary on GI[2], derived predominately from landscape and ecological sciences. However, since 2002 numerous organisations including the European Commission (2012) have refined this definition, extending its scope illustrating its added socio-economic value to landscape management.

In just a few short decades, GI has expanded beyond its North American[3] and British origins and is now emerging as a valuable concept for supporting sustainable development globally (Mell, 2016). The widespread adoption of GI rests in part in its flexibility as a concept, underpinning its potential to be used for multiple ends, facilitating communication across disciplines, communities of practice, and geographical location (Star and Griesemer, 1989; Davies and Lafortezza, 2017). Although criticised as being too broad that it means everything and yet nothing (Davies et el., 2006), it is this flexibility that brings together non-traditional planning stakeholders, as GI offers an alternative approach to "landscape" that challenges existing disciplinary silos (Garmendia et al., 2016). However, there remains only a minor literature examining how GI, as a multi-faceted framework for environmental management, has been explicitly aligned with Impact Assessment (IA) research. For example, a proportion of this literature focuses on Life-Cycle Assessment rather than IA (cf. Spatari, Yu and Montalto, 2011), and where GI has been discussed in conjunction with IA it has focussed on promoting a greater alignment, as a mechanism to deliver (and monitor) environmental policies such as off-setting and direct compensation measures (Naumann, et al., 2011).

1.1. Aligning GI and IA – a complex pairing

To understand present challenges, we trace the evolution of the GI concept, from its initial conception to its current manifestations in different geographic and socio-cultural contexts. Using a historical analysis of the principles underpinning GI found within the landscape and urban planning literature, the paper analyses how these antecedents translate into dominant discourses and, ultimately, impact upon the implementation of GI. To do this we examine the variation in approach to GI, using four analytical lenses: *temporal*, *geographical*, *scalar* and *disciplinary*. How terminology is used is paramount to this discussion, as expert and non-expert stakeholders, whether they be academics, practitioners or the public, attach meaning to specific language, ultimately influencing praxis. There are advantages to embracing diversity in GI research and practice, as it allows planners, assessment and ecological specialists, and decision-makers to be more reactive to local contexts.

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[2] Broad consensus suggests that Benedict & McMahon's discussion of GI in 2002 was the first detailed articulation of the concept. However, former Governor of Maryland Parris Glendenning used the phrase in the late 1990's during his engagement with the President's Commission on Sustainable Development (see Mell, 2016 for further details). It was also used in the 1994 Florida Greenway Commission's 'Creating a Statewide Greenway System' report but was not developed conceptually or in a practical/delivery sense.

[3] Whilst it is acknowledged that Mexico is classified as part of the North American landmass, as well as being classified as part of Latin America, there is a limited literature examining GI (e.g. Calderón-Contreras & Quiroz-Rosas, 2017.). Consequently, the use of North America in this paper refers to the established literature based in the USA and Canada.

However, it can also constrain consensus building and progression of the field, due to a lack of explicit, consistent, evidence-based parameters, as discussed in the wider IA literature (Cashmore et al. 2004; Fischer 2010). Establishing balance between these two positions will inform the argument made in this paper.

This paper aims to synthesise discussions of alignment and divergence between GI and IA research. While there are examples of GI being embedded in IA[4] practice, to date there is a limited academic literature assessing the role of IA on the field of GI (c.f. Brouwer & van Ek, 2004; Demuzere et al., 2014; Flynn & Traver, 2013; Spartari, Yu & Montalto, 2011). Partially this reflects the lack of cross-referencing between these two areas, with GI being primarily associated with landscape and urban planning practice (Mell, 2016). However, it may also reflect the lack of evaluative practice embedded in GI research and implementation (Kabisch et al. 2015). Moreover, the structure of IA potentially limits its use by researchers who favour more conceptual *and* less evaluative techniques. Where IA and GI are considered simultaneously, debate is both framed and constrained by the terminology, disciplinary perspectives and evaluation practices of its users. Indeed, even separately these challenges exist, with numerous examples of authors using the terminology of "green infrastructure" without necessarily grounding their discussions in its accepted principles (Benedict and McMahon, 2006; Firehock, 2015), just as the execution of IA can diverge substantively from its theoretical foundations (c.f. Fischer 2010).

To examine these issues, we use four axes to understand GI theory and practice, including its connections with IA. The following provides context for both GI and IA researchers to identify aspects of GI that may be useful in bridging critical gaps. However, the paper questions whether there is a need to develop a more bespoke process of "assessment" within GI research. Rather, it may be more productive to pursue integration that allows GI planning to remain rooted in its existing principles and conceptual foundations, but more effectively reflect the strengths of IA and its evaluation techniques. However, the paper does signpost that through an increased awareness of the frameworks provided by IA, investment in GI could become (a) more appropriate to local contexts, and therefore integrated more successfully, (b) be able to deliver multi-functionality more effectively, and (c) be planned to acknowledge the long-term impacts of potential socio-economic and ecological change.

1.2 Framing the analysis

The following emphasises how debate and discourse influences the trajectory of GI as presented in policy and practice. It also seeks to understand how its use as a *concept* and an *approach* has evolved

[4] Whilst Impact Assessment is an overarching term used to describe the impacts associated with specific developments or policy mandates, there are a number of types of assessment that provide more focused evaluation of the physical environment, socio-economic systems, and human health. It can occur at multiple levels to evaluate policies, plans, and programmes or assess specific impacts of proposed projects. Examples of different assessments include Health Impact Assessment (HIA), Strategic Environmental Assessment (SEA), Life-Cycle Assessment LCA), and Environmental Impact Assessment (EIA). Each has common elements but are flexible enough to address discreet issues across a range of contexts (Fischer, 2010; Glasson & Threival, 2013).

through interactions between institutions and actors. GI has been presented not just as a useful "concept", but one that promotes a holistic understanding of socio-economic and political influences, and is considered to be a contemporary approach to planning suited to addressing complex environmental challenges (Hansen & Pauleit, 2014). From this perspective, the conceptual breadth and institutionalised contexts in which GI is deployed makes it susceptible to being shaped by socio-political discourses and interactions between a wide range of stakeholders (Mell, 2016).

The four lenses used to structure our analysis are underpinned by a reflection on deliberative approaches to policy analysis, as discussed by Hajer and Wagenaar (2003). This proposes that by identifying how dominant discourses and their origins relate to the four axes presented, we can better explain the 'how' and 'why' behind the integration of GI into practice and evaluation enabling environmental advocates in landscape, ecological, water and urban planning professions to use GI more effectively (Winkel et al., 2011). The nature of the problems GI is meant to address may, however, make it vulnerable when debated against dominant economic development approaches (Robbins, 2012), but it remains a powerful tool when considered in the context of modern environmental governance where policy problems are addressed via networks of actors and institutions (Rhodes, 2007). A shift to an 'alternative' governance is most advanced in the environmental arena, in part because traditional institutions have failed to effectively address sustainability challenges. Networked, often ad-hoc arrangements often emerge to fill the gap, with collaboration offering innovative problem-solving capacity and opportunities for change (Hajer and Wagenaar, 2003; van Burren et al., 2015). The plasticity of GI is important in this process, as it can facilitate communication across networks; however, at the same time it can also be used to promote competing and often conflicting agendas (Garmendia et al., 2016).

Deliberative analysis of GI praxis (including evaluations) focuses on how disputes between discourses drive the policy process, with different "coalitions" competing to have their rival discursive concepts (e.g. ecosystem services) integrated into practice (Winkel et al., 2011). The focus is therefore on how narratives steer change. Tracking how actors "speak of change" is a useful means of analysing institutional change and/or acceptance (Schmidt, 2011). Discourse coalitions are, as a consequence, particularly useful for understanding not only the different articulations of GI, but also the relative levels of 'success' in embedding GI within different contexts, disciplines, and approaches to planning.

Discourse coalitions are described as "communities of actors" held together by shared "identity stories" (Hajer, 1993). For example, the promotion of GI for stormwater management (Hostetler, Allen, & Meurk, 2011) and biofiltration and green roofs in the USA (Kosareo and Ries, 2007); urban forestry in Canada (Duniker & Greig, 2006); and green space management in the UK (CABE Space, 2009) are such "stories", which not only bind coalitions together, but are the lens through which alternative actions can be interpreted, e.g. transitions from the implementation to GI to evaluating the actual environmental impact of an investment (Flynn and Traver, 2013). Under the discursive model of coalitions, a new discourse becomes dominant when it is a part of many actors' world view, and is subsequently integrated into institutional practices (Winkel et al., 2011). To date

such coalescence has not been developed between GI and IA, although both areas are considered to hold stand-alone consensus regarding their application. The concept, however, recognises that information and knowledge are not value neutral, and actors can differ fundamentally in their views of the world, affecting how they interpret and use information (Dovers, 2005). Understanding the conflict, buy-in, and consensus between coalitions is therefore important, as both dynamics play a role in framing institutional engagement with GI, as well as other evaluative approaches to environmental management (Hajer, 1993; 2003).

The struggle between discourses is critical not only in understanding the dynamics of how GI is governed in a particular place, but because the dominant discourse, be it economic, political or socio-ecological, helps determine which version of the concept, and which terminology, is used (Robbins, 2012). This has consequences for environmental management, and flows through every stage of the policy and implementation process, from strategic planning to delivery, management, and evaluation (cf. Firehock, 2015; Brouwer and van Ek, 2004). This way of analysing policy highlights that agents, institutions and geographic context are significant factors influencing our understanding (Schmidt, 2011) and informs the four lenses developed in the following sections (see Figure 1).

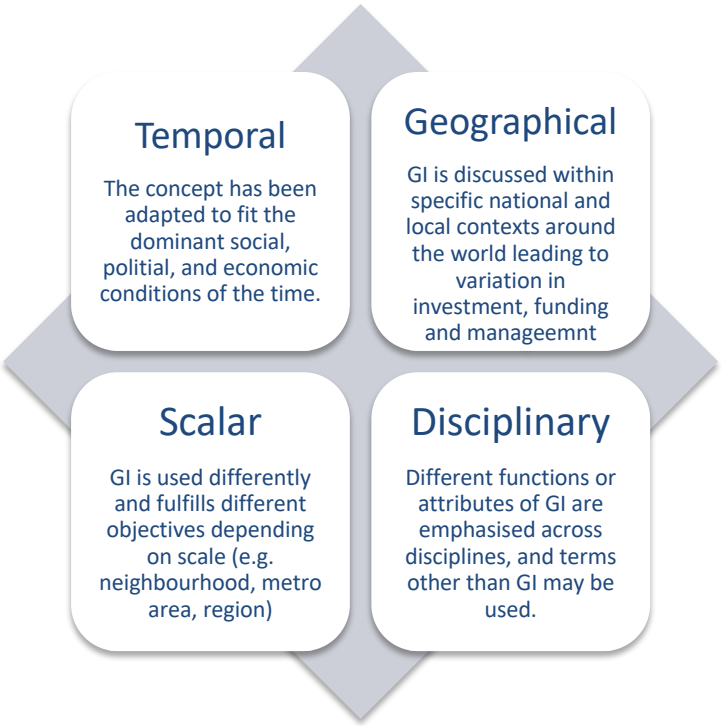
2. GI in Four Dimensions

Evaluations of GI have focussed primarily on thematically and geographically specific instances of development (Koc et al., 2017). To date there has been limited discussion examining the conceptual structure of GI, beyond the acknowledgement that it should be guided by the key principles of connectivity, accessibility, multi-functionality, and provision of benefits to a variety of social and ecological systems (Austin, 2014; Benedict & McMahon, 2006; Rouse & Bunster-Ossa, 2013). The literature also states that its advocates are promoting GI as a context-driven and scale-dependent form of investment that can be used to integrate alternative knowledge systems (Mell, 2016). These principles have permeated praxis across the UK, parts of Europe (e.g. Scandinavia), and North America, predominately the USA, over a twenty-year period, helping to establish GI as a prominent approach to green space planning (Mell, 2016). GI has not, however, overtaken locally specific approaches to environmental planning, e.g. landscape planning in Germany (Fischer, 2016; Davies & Lafortezza, 2017). In such cases, GI is seen to be working in conjunction with existing practices to promote ecological management and evaluation practices (Hansen et al., 2019; di Marino & Lapintie, 2018). The extent of local influence on the application of GI in practice (and vice versa) is varied, thus there is a need for considerations of *temporal, geographical, scalar* and *disciplinary* factors to be made in such discussions of GI. These four axes[5] have been identified from an extensive review of

[5] Implicit within these four axes is an understanding of historic changes/evolution in planning and management practices, socio-cultural and economic variation in approaches to landscape, and the role of political support/will in driving forward projects, programmes and policies related to GI (Robbins, 2012). We acknowledge that each of these four axes is therefore subject to considerable change, however, from a review of the GI literature they remain the most prominent factors influencing its development.

published academic and practitioner GI literature including a reflection on the growing number of GI review papers (cf. Wang and Banzhaf, 2018; Escobedo et al., 2019; Garmendia et al., 2016, Hansen & Pauleit, 2014; Davies & Lafortezza, 2017; Lindley et al., 2018). The review of this literature identified consensus for the principles of GI, and barriers to its use and subsequent evaluation, the latter being significant in framing the four axes. The following section maps how these four factors have influenced the development of GI over time, and how its use varies across each axis. It also highlights areas of potential alignment where IA, and specifically where Environmental Impact Assessment (EIA) and Strategic Impact Assessment (SEA) could be integrated more effectively into GI discussions to provide greater structure and reflection for both the strategic system and elemental discussions embedded within GI thinking.

Figure 1. The four dimensions influencing GI as a concept and in practice (source: authors)



2.1. Temporal

Key to GI's development has been the integration of historic approaches to landscape planning from across the UK and North America, and to a lesser extent northern Europe. Since the 19th century, significant emphasis has been placed on the role of "landscape" as a civic asset following the proposals of Ebenezer Howard and Frederick Law Olmsted in the UK and USA respectively, promoting health, well-being and engagement with nature (Thompson, 2011; Little, 1990). This was a response to the environmental impact of industrialisation and the socio-economic conditions of workers, shifting the view of landscape from it being an aesthetic asset to green space as a provider of multiple ecological and social values in planning (Howard, 2009). Such changes are evident in the Greenways

and Garden Cities literature, which identified landscape functionality, connectivity, and socio-cultural attachment to nature as key delivery principles (Ignatieva et al., 2011). We can further trace this evolution through the environmental movement of the 1960's in North America, e.g. within McHarg's (1969) *Design with Nature*. The 1960's also saw the initial development of EIA in the USA and subsequent exploration in the EU and globally, as a response to significant environmental change (Morrison-Saunders & Arts, 2004).

In line with this broader social movement, green space became viewed as a means to ameliorate the effects of increasing urbanisation, with some jurisdictions in the UK, USA, and more recently China, introducing explicit open space standards into urban planning (Byrne, Sipe and Seale, 2010). Moreover, the growth of urban greening, urban forestry and nature-sensitive planning has further integrated socio-economic and ecological benefits into discussions of environmental management (Schaltegger and Synnestvedt, 2002). This is consistent with broader shifts in the way environmental problems are addressed, especially with respect to concepts such as sustainability, ecosystem services, and IA, all of which emphasise the interplay of ecological, social, and economic dimensions of landscapes (Ness et al. 2007).

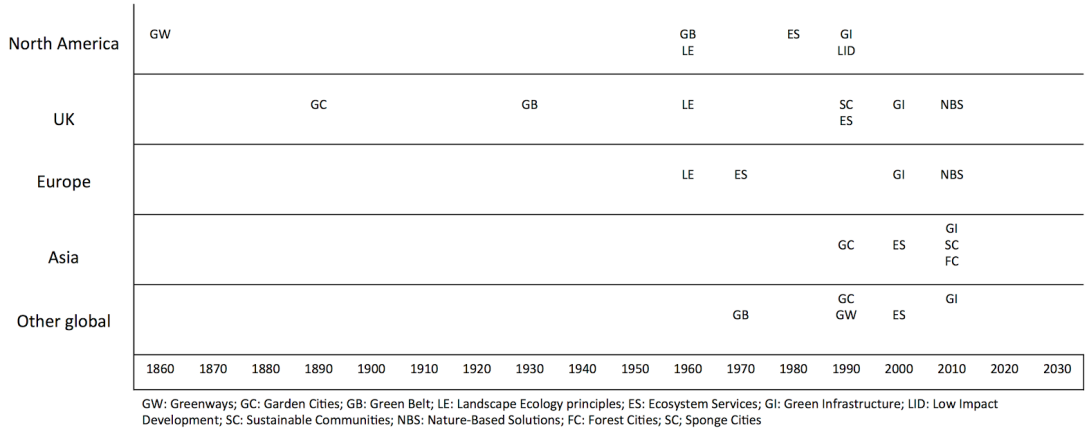
When the antecedents of GI are discussed against then growing awareness of environmental change from the 1960's onwards facilitating the development of IA, specifically EIA in the USA, we can highlight how alternative forms of assessment are evaluating the "higher order changes" and impacts being placed on landscape resources (Wood & Dejeddour, 1992). Thus, as environmental management became more prominent in policy and practice the additional structure provided by IA to advocates enabled them to assess and mitigate negative landscape change. Processes that are now becoming embedded within GI thinking (Lovell & Taylor, 2013).

Viewing GI through a temporal lens also highlights the changing influence of management and monitoring practices embedded within landscape planning. As Firehock (2015) and Rouse and Bunster-Ossa (2013) discuss, investment in GI is only part of the equation. They argue that without effective management programmes, including monitoring, GI will fail to deliver ecosystem services, e.g. within biofiltration or green roof projects (Flynn & Traver, 2013; Kosareo & Ries, 2007). England's Community Forest Partnerships supported these arguments, calling for environmental rehabilitation, using GI as part of an integrated approach to managing landscapes aligning socio-economic and ecological enhancement with more effective governance (England's Community Forests & Forestry Commission, 2012). The emphasis placed on monitoring builds on broader discussions of multi-functional landscapes, where adaptive management literature stresses the importance of continual adjustment based on feedback to improve decision-making (Tompkins and Adger, 2004). Thus, opportunities potentially exist for GI advocates to engage more directly with the processes embedded within SEA at a landscape scale and EIA at more discreet scales to provide additional structure to management practices; especially where socio-economic issues are given primacy over environmental concerns (Morrison-Saunders & Fischer, 2009). It is notable that discussions of the promises, pitfalls, and uneven execution of monitoring are occurring concurrently in the GI, IA, and broader

environmental management literature, appearing to peak in the 1990s and early 2000s (c.f. McLain and Lee 1996; Arts et al. 2001).

This mirrors broader changes in environmental governance, which are shifting toward more collaborative and devolved, networked governance (Sullivan et al., 2013). It is thus unsurprising that the GI literature is increasingly marked by an emphasis on questions of how, why, and by whom green space can be managed (Hansen and Pauleit, 2014). The debate has progressed from simple discussions about investing in GI to assessing *what* GI is needed, *where* it is needed, and *how* it's benefits can be managed and evaluated (Meerow and Newell, 2017). The growth of literature on the environmental impact of GI is perhaps greatest in North America, where the management of stormwater is paramount to comply with Federal and State laws (Wise, 2008). Progress has been slower in terms of including GI in strategic and environmental IA in other locations, which reflects the challenges of multiple, sometimes competing sectoral objectives attempting to align theory, practice and evaluation (Demuzere et al., 2014; Sharifi & Muruyama, 2013; Fischer et al., 2018).

Fig. 2. Evolution and use of green space terminology since 1860



GW: Greenways; GC: Garden Cities; GB: Green Belt; LE: Landscape Ecology principles; ES: Ecosystem Services; GI: Green Infrastructure; LID: Low Impact Development; SC: Sustainable Communities; NBS: Nature-Based Solutions; FC: Forest Cities; SC; Sponge Cities

(Derived from: Wang and Banzhaf, 2018; Escobedo et al., 2019; Garmendia et al., 2016; Benedict & McMahon, 2006; Mell, 2016; Sinnett et al., 2015; Austin, 2014; Hansen & Pauleit, 2014; Little, 1990; Davies & Lafortezza, 2017; Firehock, 2015; Lindley et al., 2018; Tzoulas et al., 2007)

Applying a temporal view also provides an opportunity to assess the divergence of types, amenities and values associated with GI. This includes reflections on the value of landscape-scale trails within the greenway literature, biodiversity in urban landscapes, and the role of evaluative tools in water management or green technology (Flynn & Traver, 2013). Looking at GI from a temporal perspective allows us to identify how specific approaches to planning have evolved to shape the current use of the concept (Wright, 2011). This suggests that practitioners using established approaches, as information brokers of environmental protection, i.e. SEA or EIA, could be integrated more effectively in long-term management strategies, although actioning this is not without its difficulties (Slootweg, 2016). Figure 2 illustrates the development of GI and associated terminology in different geographical context (although existing language and structures remain prominent in many

locations). Such evaluations expand the expectations for what GI can achieve (Roe and Mell, 2013), as it is increasingly viewed as a tool to solve an ever-widening range of social, economic, and environmental challenges (Raymond et al., 2017).

2.2. Geographic

The research literature suggests geographically nuanced conceptualisations of GI, revealing a distinct set of discourses associated with environmental planning, management and, to a lesser extent, evaluation. Each approach to GI, as described by Mell (2016) and Austin (2014) is underpinned by thematic understandings of landscape, e.g. in terms of water management, ecosystem services or socio-cultural value; however, the employment of this information varies across national, regional and local contexts. For example, the prominence of the Clean Water Act (1972) in the USA structures GI towards stormwater management, as this is tied to funding and statutory environmental requirements (Foster, Lowe & Winkelman, 2011). In Europe ongoing discussions locate GI within landscape-scale assessments of environmental management, consistent with landscape planning traditions which have been evident since the 1970's in Germany (Mell et al., 2017), and associated with ecological enhancement in urban areas in Belgium and The Netherlands (c.f. South Yorkshire Forest Partnership & Sheffield City Council, 2012), and with urban rehabilitation in the UK (Kitchen, Marsden, & Milbourne, 2006). Although approaches to GI are not necessarily tied to legislative mandates in all areas of western Europe, as in the USA, they do reflect the ideologies of the five major 'planning schools of thought in Europe' proposed by Newman & Thornley (1996)[6], with GI appearing within localised environmental assessments (Davies & Lafortezza, 2017). Where coalescence has occurred in Europe it has been linked most frequently to EU funding, e.g. associated with urban greening and NBS (Kabisch et al., 2016; Vandermeulen *et al.*, 2011). Within other international contexts, academic and practitioner knowledge of GI has been integrated into delivery programmes to make it work in different national contexts (Austin, 2014). Geographically distinct consensus is thus emerging between countries and planning traditions, shaped by relevant policy and available resources, as is increasingly evident in the academic and grey literature.

In practice this has led to geographic variation in which "function" or "benefits" of GI are promoted. While more emphasis is placed on water management, especially stormwater in North America (Young et al., 2014), in Europe discussions focus on an integrated approach to ecological and socio-economic improvement although different terminology is used (Garmendia et al., 2016), which is aligned with existing green space planning approaches and newer terminology such as NBS. Consequently, although the core principles of GI are visible in all regions, their application differs (Davies & Lafortezza, 2017). For example, in China GI has been used to enhance the landscape quality of housing development, aligned with economic development (Li, Wang, Paulussen, & Liu, 2005; Jim

[6] The five main traditions of European planning thought are: British, East European, Germanic, Napoleonic and Scandinavian. However, there are ongoing discussions as to whether these five 'traditions' remain appropriate in contemporary European planning.

& Chen, 2007). In this way GI is being used as a economic tool by decision-makers and developers to ensure the specific investments, e.g. those named as eco or sponge cities, are approved for delivery (Wu, 2015). However, in Western Europe, e.g. The Netherlands, we can identify a greater number of discreet projects using GI to improve specific sites (Vandermeulen et al., 2011). Although these may form part of a wider 'greening' agenda, GI investments are frequently compartmentalised compared to the investment strategies in China (Mell, 2016). Development practices in North America are potentially a hybrid of these approaches, as practitioners employ GI across a continuum of scales. As a consequence practitioners in the USA are more likely to approach GI investment and evaluation techniques from a systems perspective aligning hydrology, arboreal and ecological knowledge within landscape and urban contexts compared to their counterparts in China or Europe (Schilling and Logan, 2008; Young and McPherson, 2013).

There are also geographically distinctive terms used to support GI, sometimes driven by conceptual foundations but often driven by local policies and political narratives. Whilst GI has currency as the prominent approach to green space planning in the UK and USA, there remain myriad discussions focussed on the utility of Greenways, Garden Cities, Green Belts, NBS, urban forests, and sponge or forest cities in Europe and Asia. Each sits within a specific geographical context with Greenways retaining a prominent position within the USA (Hellmund & Smith, 2006), Garden Cities being located within a UK planning context (Howard, 2009), and urban forestry holding resonance in Canada and Europe (Konijnendijk et al., 2006). Within this debate "green space" is a ubiquitous term transcending location but focuses most frequently on urban issues neglecting the wider landscape functions explicit within GI debates. Driven by EU funding, NBS are becoming established as a pan-European approach to landscape planning, whilst sponge and forest cities are the latest articulations of the Chinese government's ambition to create "sustainable" places (Kabisch et al., 2016; Li et al., 2017). Moreover, in the developing contexts of Latin America, e.g. Brazil, and east and southern Africa we can identify a range of terminology used that is (a) reflective of local environmental contexts, (b) framed by the interaction or exposure of scholars and practitioners to the varying conceptual approaches to green space management and (c) is based on local terminology and decision-making practices (Koc, Osmond, & Peters, 2016; Escobedo et al., 2019; Lindley et al., 2018).

Such divergence affects the extent to which monitoring and evaluation are undertaken. This is reflective of the structures used to manage landscape resources but also illustrates the political complexities associated with monitoring the effectiveness of investment in GI (Rouse & Bunster-Ossa, 2013). For example, the alignment of GI with stormwater management and federal funding ensures evaluation is formally integrated in practice in the USA. This focuses on cost-benefit analysis of investments in GI, ensuring that a level of monitoring is programmed into development strategies (Firehock, 2015). The same level of evaluation is not visible in all GI arenas, e.g. the UK, as monitoring is considered to be (a) not legally required, (b) surplus to requirements or (c) a revenue cost not factored into capital investment or maintenance in investment programmes. Moreover, there is an ongoing dialogue between planning and environmental specialists regarding whether IA is (or should

be) a requirement of GI or landscape planning. This process is influenced by the broader institutional norms of the planning system within which investment is made. Where strong environmental regulations exist, e.g. in Germany, a greater level of monitoring is embedded in policy frameworks (Knill & Lenschow, 1998; Wende, 2002). However, where weak environmental regulation is visible, e.g. in China, evidence of GI delivering ecological, flooding, or climate change improvements is less established (Sinnett et al., 2015).

2.3. Scalar

Alongside temporal variation in GI thinking is a corresponding spatial or *scalar* element that has been used by stakeholders to manage the landscape. A continuum of scales underpins investment in GI, its effectiveness as a form of environmental management, and helps promote the concept within a practitioner toolkit of development (Young & McPherson, 2013). GI can therefore be considered to function at the micro-scale, as illustrated by the green streets and alleys research in Los Angeles (Beatley, 2016; Newell et al., 2013) and at a landscape scale, e.g. water catchment management (Keesstra et al., 2018).

As GI has matured as a concept, so too has understanding of its cumulative value to society, the environment, and the economy[7]. Considering it in this way shifts the emphasis from narrow approaches to environmental planning and management, where emphasis has historically been on direct impacts, individual sites, or species in isolation (Clement et al. 2015a; Mell, 2016). The variation in the scale of investment and understanding of value are in part socio-politically driven. Investments in China and South Asia view large-scale developments as having a greater number of potential GI benefits, however, this can fail to take into account local socio-cultural uses or ecological knowledge (Byrne, Lo, & Jianjun, 2015). Where planning is devolved to individual organisations or communities in Asia, Europe, or North America, localised approaches may reduce the understanding of GI as a network of spaces that function collectively (Young, 2011). Consequently, political support, effective tiering, and decision-making based on robust evidence of socio-economic and ecological and/or climatic impacts, are needed to ensure GI is delivered effectively. Structured evaluation processes can enhance this functionality, so it is notable that similar discussions of scale are embedded in the IA literature. For example, SEA and cumulative effects assessment are increasingly highlighted for their potential to influence policy and decisions at a landscape scale; but if it is not effectively tiered within the decision making process – or if strategic issues are not resolved or accepted by local stakeholders – conflicts are often transferred to project EIAs (c.f. Sánchez and Silva- Sánchez, 2008).

By situating GI thinking within a similarly tiered framework, there is potential for greater alignment with IA. SEA works at the highest levels of decision making to assess impacts at the policy,

[7] Cumulative value is a scalar issue, as the size of a GI resource does not necessarily align directly with its socio-economic or ecological value. Size is a relative factor in discussions of value, but there is a need to examine how the continuum of GI resources can provide multi-functionality (Davies et al., 2006). The ways in which values can be cumulatively developed therefore sits most easily within issues of scale.

plan, or programme level, whilst EIA assesses the impacts of change at a thematic or elemental level. Praxis in GI has developed at both levels, with practitioners incorporating strategic ecological thinking into policies, plans and programmes, specifically those focussed on water or ecological management. Many practitioners focus on small-scale GI, but increasingly they need to promote the cumulative value of GI in urban areas to rationalise investment. Synergies between the two fields offer value to both, with EIA and SEA providing structured evaluation frameworks and mechanisms for embedding GI into all tiers of decision-making, and GI providing an understanding of the dynamic social-ecological aspects of development to IA (Garmendia et al., 2016; Cord et al., 2017).

Drawing on landscape ecology principles, GI views the landscape as modular, i.e. as a spatially heterogeneous network of spaces that are connected in a broader ecological network (Jongman & Pungetti, 2004). Although the network metaphor implies GI is considered at a landscape scale, in practice stakeholders compartmentalise the concept into spaces that are individually assessed *and* viewed as being part of a wider network (Firehock, 2015). Thus, effective GI planning promotes the ecological and socio-economic value of a specific GI element but locates this within a broader approach to management (Benedict & McMahon, 2006). When paired, IA and GI provide multi-scalar concepts that, if aligned more effectively could help frame both landscape and neighbourhood-scale management.

Larger scale resources are especially prominent in discussions of how GI can be used to solve climate change and biodiversity loss (Clement et al. 2015a). As a concept that addresses the drivers of ecosystem decline across different sectors, is relevant across political portfolios, and crosses jurisdictional boundaries, GI has the potential to address these issues (Collier, 2015; Matthews et al., 2015). It is here where the network perspective on GI is particularly relevant and is helping to modernise environmental policy. While small GI elements have social value, they may make limited contributions to addressing habitat loss caused by urbanisation, but urban ecologists have demonstrated that attention to fragmentation, connectivity, quality, and native species richness at a landscape scale can make significant contributions to biodiversity (Kong et al., 2010; Threlfall et al., 2015). Herein lies one of the most significant intersections of IA and GI: the development and application of strategic frameworks for investment that assess the types, functions and impacts of development with the view of minimising potential negative outcomes. Consequently, SEA can be used to structure reactions to “higher order actions” and EIA can be used to address more localised issues (Wood & Dejeddour, 1992).

What makes GI ‘functional’ at a landscape scale is quite different than when viewed at the micro-scale, and is where a coordinated approach to management is a more appropriate lens for management than traditional greenspace assessments (Hostetler et al., 2011). The use of a systems perspective illustrates the importance of a portfolio approach to GI policy, implementation and evaluation, i.e. where collaborative dialogue and planning leads to a more appropriate mix of regulatory (e.g. administrative laws) and non-regulatory policies, plans and programmes (e.g.

incentives) (Clement et al., 2016), it also highlights a potentially key, but so far underutilised, role for strategic IA in ensuring larger scale objectives are established (Clement et al. 2015b).

2.4. Disciplinary

Discussions and different perspectives among stakeholders from alternative disciplinary backgrounds have substantially impacted upon the development of the GI concept. Disciplinary variation in the conceptualisation and implementation of 'landscape', and more recently GI, is well known (Benedict & McMahon, 2006; Sinnett et al., 2015). As GI has developed independently within disciplines, and subsequently through cross-disciplinary dialogue, it could be described as being both intently specialist yet inherently inclusive (Koc et al., 2017). This diverse disciplinary foundation has created a broadly salient, yet malleable, concept, enabling actors from different sectors to apply GI in practice without undermining their disciplinary principles, as seen in GI praxis for stormwater and ecosystem services (Hansen & Pauleit, 2014). Such differences were evident in how social scientists highlighted the value of GI from a human-centred perspective (Mell, 2016). Whereas ecologists draw attention to the different technical and qualitative aspects of GI by linking it more directly to the ecological dimensions of environmental challenges (Kong et al., 2010; Hostetler et al., 2011). Variability is also evident in discussions in urban forestry (cf. Duinker and Greig 2006; 2007) and ecosystem services (Liquete et al., 2015; Weber, 2007), as well as in those related to the role of landscape in promoting real estate value (Jaffe, 2010; Jim & Chen, 2007). Furthermore, where GI is aligned with IA, we see a more structured analysis to investment, such as emphasis on specific tools (e.g. life-cycle assessment) and other forms of evaluation (Sharifi & Muruyama, 2013; Kesareo & Ries, 2007). This suggests disciplinary silos lead to incongruous approaches to GI; however, diversity also provides scope to incorporate more disciplines and draw on a wider range of knowledge (Lennon & Scott, 2014), which can lead to the creation of a portfolio of strategies that more effectively address social and environmental challenges (Young et al., 2006).

There are concerns, however, if these disciplinary discussions dominate the debate regarding what GI means and how it should be implemented. Given the origins of GI as a concept within landscape and subsequently urban planning, the value of this cross-pollination can be a way of facilitating change and institutionally embedding GI through co-production of knowledge (Sinnett et al., 2015). It is recognised that building technical and administrative capacity for knowledge exchange is essential to achieving systemic change in governance systems (Van Kerkhoff and Lebel, 2015). To do this requires embracing not just expert knowledge, but also the integration of non-expert stakeholders embedded in the communities of practice where GI is being implemented. In urban contexts where the application of GI is most prominent, it has been argued that disciplinary perspectives have come to dominate discussions but may actually block more sustainable forms of planning (Munoz-Erickson, 2014). Co-production therefore draws attention to how both normative and contextual factors influence the ways in which knowledge is used and how new approaches become established (Van Kerkhoff and Lebel 2015). Co-production offers a useful lens for GI, as it

highlights that disciplinary, expert knowledge sits alongside stakeholder discussions regarding scientific, and social data and cultural preferences, shaping debate and implementation (Koc et al. 2017; Escobedo et al. 2019). In practice we can see how disciplinary biases, e.g. selection of terminology, approaches and geographical focus, limit the nuanced understanding of GI that is more clearly seen in transdisciplinary approaches to investment.

The dynamics of co-production across GI stakeholders could, however, limit the consensus of what GI is and how it should be planned. Moreover, marked disciplinary differences can create tensions within political decision-making in terms of supporting GI, its funding, and subsequent implementation (Mell, 2017; Young & McPherson, 2013). This mirrors discussions in political ecology, where stakeholders position themselves to shape GI, contesting the validity of alternative views in the process (Heynen, Perkins, & Roy, 2006; Robbins, 2012). To date there has been a relatively successful adjustment to diverging discourses, using the principles employed by Benedict & McMahon (2006) to structure GI. However, there is a growing debate within GI planning about the need to champion green space as an economic investment (Ecotec & Sheffield Hallam University, 2013), reframing political discussions and advocating for GI to move away from only delivering its core principles towards a more explicit economic focus (Lovell & Taylor, 2013). Thus, although we can identify coalitions of authors, disciplines, and projects utilising a complementary set of GI principles, there remain differences in what is emphasised within GI praxis (Koc et al., 2017), driven in part by the disciplinary lenses of GI advocates.

3. Discussion and Implications

Despite GI exhibiting conceptual and practical variation across temporal, geographic, scalar, and disciplinary dimensions, there is evidently general acceptance of a grounded set of principles including multi-functionality, access to nature, connectivity, and integrated approaches to management (Sinnett et al., 2015). GI has also been called “old wine in new bottles” (Davies et al., 2006), suggesting that although the fundamental ‘ingredients’ are established, the way in which these are packaged varies according to geographical contexts, disciplinary perspectives, and discussions of scale, as relevant for a particular planning activity. At the same time, use of GI terminology has been beneficial for moving conversations forward with a broader audience, moving from siloed discussions of “landscape” towards a collective, and in many cases co-produced, understanding of the environment as a multi-faceted entity that serves multiple ecological or socio-economic functions (Davies & Lafortezza, 2017; Hansen & Pauleit, 2014).

Consequently, a clustering of projects, policies and advocates can be identified within GI research, creating a “circling of discourses” that, although independent, necessarily intersect in practice. By reviewing variation across our four axes, two very distinct discourse coalitions emerge. One is comprised mainly of social scientists and planners who emphasise the importance of GI from a human perspective; highlighting the benefits of even small-scale GI on aesthetics, community cohesion, and health (Tzoulas et al., 2007). In contrast, a second coalition of actors, comprised

primarily of natural scientists, emphasise the need for large-scale GI to perform ecological, water management, and climate regulation functions (Cohen-Shacham et al., 2016). This second coalition tracks with broader trends in environmental management, shifting from small-scale (e.g. single species) through intermediate (e.g. habitats) to large scale development (e.g. landscapes, bioregions, and ecosystems) (Jonhman and Pungetti, 2004). Although similar tensions exist within IA research and practice, IA could offer a more effective evaluation frameworks and institutional regimes, which would be better able to accommodate both discourses. SEA provides a way to consider broader principles and landscapes as in the second discourse, while EA attends to the local interests of the former and Sustainability Assessment (SA) is potentially a way to move beyond the demarcated pillars of sustainability (i.e. society, economy, and environment), aligning it with more systematic approaches to landscape planning (Fischer 2010; Gibson 2006). While this may not be sufficient for achieving the broader, systematic changes needed in urban areas, it offers a clear pathway for mainstreaming GI within existing institutional pathways (Young et al. 2014).

The understanding of "quality" also varies across these coalitions, with the first emphasising social perceptions, e.g. access to nature as an amenity leading to "value" being attributed where species richness and ecological function may be relevant but not essential, whereas the latter coalition would view these as paramount. The "value" of a resource and the impact those have on management are also fundamental principles of IA and provide the techniques and mechanisms useful for collaboration and multi-disciplinary working (Fischer, 2010). Ultimately, it seems that both coalitions understand GI as "multi-functional" but differ in terms of *which* functions they emphasise. This is not unlike IA, which encompasses a wide range of tools for assessing multiple impacts, but legal requirements are often focussed on one particular dimension (e.g. environment, health, social impacts). Moreover, while GI is often depicted as a multi-functional concept where all functions are equal, in practice this is not the case. Rather than being problematic, this underscores the flexibility of GI, enabling it to be employed to solve problems in a variety of locations (Mell, 2016).

An examination of the geographic axis reveals the importance of framing GI in terms of the political priorities of a place, based on political positions, evaluative frameworks and disciplinary ideas and agendas, suggesting that localised discourse coalitions can come to supersede academic narratives. Moreover, although there will be temporal variation in which discourse coalitions are most successful, it is clear that certain 'storylines' about what GI is, what it can do for society and the environment, and how it should be implemented dominate a given geographic context if political, public or private actors are able to provide a clear understanding of GI that aligns with funding, regulatory and evaluative drivers. It is in these spaces that the lack of alignment between the mainstream GI research and IA is most visible. While there is well-established literature on evaluation, there is insufficient cross-referencing with the GI literature. The result is a lack of systematic reflection or cross-disciplinary interaction in the development of GI policy and practice from an evaluative perspective. Therefore although the number of GI advocates is increasing highlighting the

value of GI investment, such value is rarely integrated within IA or other systematic evaluations practices.

Even where GI is successfully embedded in urban planning in UK of USA (Mell, 2014), its use is dependent on specific pathways and institutional arrangements. We can argue that this reflects different approaches to terminology, the capacity of individuals or institutions, training and subsequent awareness and interaction of IA and GI. Moreover, advocates of both GI and IA are potentially guilty of reinforcing "silos" prompting debates about how to promote more integration and reflection to improve efficiency and effectiveness (c.f. Morrison-Saunders et al. 2014; Lennon and Scott 2014). Importantly, where one storyline is deemed politically palatable, it may be used simply to 'green' existing practices, rather than to disrupting 'business as usual' to effective address social and environmental challenges facing communities (Koontz et al., 2015).

It is in this debate where both IA and GI face a similar challenge. While each aim to challenge the status quo and have done so in specific circumstances, both have been criticised for reinforcing normative practices, whether through misapplication or manipulation by influential actors (c.f. Nykvist and Nilsson 2009; Cashmore et al. 2010; Matthews et al. 2015). This is not unique to either domain and in part reflects broader challenges in environmental management, where sustainable transitions require overcoming institutional barriers, such as a bias toward the status quo and habitual behaviour; and such path dependencies make change difficult to engineer (Scott, 2014). Overcoming these barriers is essential to effective sustainability transitions, although intentional environmental governance reform remains a significant challenge (Clement et al., 2015a). An additional factor accounting for geographic variation in GI implementation relates to the fact that we can identify competing financial and socio-cultural rationales for urban greening (Wright, 2011). When we add to this complexity the fact that many government agencies, private and non-profit organisations, and community actors have a stake in GI, operate at different scales, and hold diverse political agendas, even if common ground can be found to form a discourse coalition, widespread adoption of GI depends upon a successful re-organization of this complex network (Matthews et al., 2015). Much like 'shadow networks' that have been shown to increase institutional learning and facilitate change, these discourses can provide new storylines as socio-political influences change (Olsson et al., 2006).

As with other modern concepts in environmental management that have been criticised as being ambiguously defined or all-encompassing e.g. resilience or sustainability, it is also worthwhile considering whether this variability in GI thinking is functioning as a 'boundary object' and/or as a 'bridging concept'. Boundary objects are concepts with interpretive flexibility, which are shared by several communities but used differently by each, allowing them to be negotiated over time (Star & Griesemer, 1989). Viewing GI as a boundary object would explain the circling but lack of intersection of discourses both within the field and between IA specialists and landscape-centric GI advocates. Boundary objects are useful for stimulating communication across disciplines, communities of practice, and cultures, although progression from communication to integration is not guaranteed.

Thus, the presentation of ideas can generate interest but does not guarantee change in institutional thinking or practice. Bridging concepts, in contrast, actively link and stimulate dialogue across fields leading to more integrative actions (Deppisch & Hasibovic, 2013). Discussions of the role IA can play in advancing GI could therefore centre on the alignment of natural and social science to bridge the gaps between design, implementation, management and evaluation visible in environmental policy/practice. By integrating the evaluative structures of the various types of IA, GI thinking could be supported by additional ex-ante and ex-post assessment mechanisms to support more effective delivery and management. The dynamic approaches of both are necessary to foster the sort of institutional knowledge required to effectively address complex, multi-level, and cross-sectoral environmental and social challenges (Deppisch & Hasibovic, 2013). From our analysis, GI is viewed as being relatively successful as a boundary object, stimulating dialogue between disciplines and providing a common framework that can be used and interpreted flexibly depending on the disciplinary background, geographical context, and scale of interest. While at times it has been used to stimulate discussion across these different communities, it has been less effective as a bridge between the social and natural sciences and wider assessment practices.

4. Conclusion

While the process of exploration, expansion, and consolidation has helped GI mature as a concept, there remains distinct variability in the way in which it is implemented. While flexibility is one of its strengths, we argue that some degree of harmonisation, developed through discourse coalitions, will help advance the use of GI in environmental planning and assessment. From this analysis, it is clear that these factors interact with socio-political and economic drivers in the broader context, shaping how terminology is used. To some extent this variability is essential, if the concept is to fit within changing social, political, and economic discourses. Thus, while these debates have advanced the use of GI, it is evident that 'silos' remain in its use, affecting efforts to embed the approach within landscape and environmental planning through consensus building. These discussions also illustrate the lack of a specific literature analysing environment assessment and GI collectively. This raises questions regarding the potential to align the approaches of environmental researchers and practitioners in terms of their conceptual, implementation and evaluative practices. Therefore, from the discussion outlined previously an ongoing influence of the four axes: *temporal, geographical, scalar* and *disciplinary* on the use of GI in landscape planning was highlighted. It is also possible to identify a growing acknowledgment within the academic literature of a discourse coalition supporting the principles of GI set out by Benedict & McMahon (2006), Austin (2014) and Mell (2016). However, we question whether a universal alignment of GI and IA would be beneficial if it curtailed the application of local knowledge, disciplinary approaches or an acceptance of landscape change over time. Consensus can be viewed as a positive if, and where, it helps progress GI within planning and environmental praxis. A rigid conceptual or evaluative framework should not though be established limiting GI if positive outcomes fail to materialise, especially in locations where strong political or

institutional support for investment can be identified. Treating GI as a boundary object thus provides flexibility that can be used by multiple disciplines and in multiple policy domains, even beyond GI and IA experts. Such flexibility allows knowledge exchange across geographic contexts, spatial and temporal scales, and between disciplines. Moreover, cross-pollination can enhance understanding of its value and promote widespread delivery. However, boundary objects often fail to enhance integration across these various domains. If it is therefore important to retain the core principles underpinning GI and limit the circling of discourses currently evident in research and practice. The focus should instead be on how to enhance alignment across the four axes to further develop GI as a concept and align it with IA processes in planning practice. By enhancing links between disciplines, geographies, and scales, there is the potential to enhance learning across GI and IA to the benefit of both fields.

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